MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 1, 2016/2017

EMG4066 – ANTENNA AND PROPAGATION

(TE)

18 OCTOBER 2016
09.00 a.m.–11.00 a.m.
(2 Hours)

INSTRUCTION TO STUDENT

1. This Question paper consists of 4 pages including cover page with 4 Questions only.

2. Attempt **ALL** questions. All questions carry equal marks and the distribution of the marks for each question is given.

3. Please print all your answers in the answer Booklet provided.

Question 1

(a) Find the directivity of a short dipole as a function of the directional angles.

[10 marks]

(b) i. Find the maximum directivity and gain of the antenna above and express it in decibels. Assume that the antenna element is lossless with an efficiency k equal to 1.

[3 marks]

ii. If the efficiency of the antenna above is 50%, the VSWR at the antenna input is 3 and the input/supplied power is 1 W, find the antenna gain and the total radiated power of the antenna.

[8 marks]

(c) Explain reciprocity theorem in the context of antennas.

[4 marks]

Question 2

(a) Draw the equivalent circuit of a receiving Hertzian dipole and derive the expression of its effective aperture as a function of directivity D and wavelength λ .

[8 marks]

(b) Explain a transverse electromagnetic wave with the aid of a diagram. State two equations which describe the relation between electric field intensity (E) and magnetic field intensity (H).

[5 +2 marks]

(c) An antenna radiates only into the upper hemisphere and its normalized radiation intensity is given by $U(\theta,\phi)=\cos^2\theta$. Calculate the total radiated power of the antenna.

[5 marks]

(d) A uniform linear array consists of 10 half-wave dipoles with an inter-element separation $d=\lambda/4$ and equal current amplitude. Find the excitation current phase difference β such that the main beam direction is at 60° $\left(\phi_{max}=60^\circ\right)$.

[5 marks]

Question 3

(a) Explain in brief the structure of ionosphere with the help of a diagram.

[8 marks]

(b) A short wave link broadcasts via the ionospheric E-layer. The critical angle and the virtual height at the midpoint of the path are 60°(with respect to vertical plane) and 80km respectively. Calculate the maximum service range obtained in a single-hop transmission via this layer when the greatest virtual height is 100km. The radius of earth is assumed 6400km.

[7 marks]

Continued...

(c) Sky wave communication between two points on earth's surface at a distance 2500km is to be established using reflection from F1 layer at a virtual height of 200km. The critical frequency is 4 MHz at the reflection point. The effective Earth radius due to refraction, R' is 8500km.
i. Determine the electron density at the reflection point
ii. Find the maximum usable frequency (MUF) and the optimum working frequency (OWF)
iii. Ignoring collisions, determine the refractive index of ionosphere at 200km virtual height for OWF. Discuss this result.

[2+4+4 marks]

Question 4

(a) A police patrol car with an antenna on the rooftop of the car approximately 1.5m above the ground is communicating with another patrol car and the nearby police station. The police station uses a central dispatcher with an antenna at the rooftop of the police station with 15m high. Calculate the maximum communication distance:
i. Between the central dispatcher at the police station and a patrol car
ii. Between the two patrol cars

[4+4 marks]

(b) Your cell phone transmits at a power level of 500 mW, and an antenna gain of 2 dBi. The cell tower has an antenna gain of 8 dBi, and for LTE, you're transmitting at 700 MHz. How far from the tower could you be while maintaining the capability to communicate? (Cellular "dead zone" occurs when the receive power $P_r < -110$dBm)

[4 Marks]

(c) A transmitter with an antenna gain of 40dB radiates a power of 20 watts operating at 8GHz frequency. The receiver uses a similar antenna and is located at a distance of 60km. Determine the received power in watts at the receiveing antenna.

[8 marks]

(d) What is meant by diffraction of radio waves and under what condition does it arise?

[5 marks]

End of paper.

APPENDIX

Constants and Formulae (All symbols have their usual meanings)

Constants and Formulae:

Boltzmann's constant	$k = 1.38 \times 10^{-23} J/k$
Plank's constant	$h = 6.6266 \times 10^{-34} J.s$
Light velocity in free space	$c = 3 \times 10^{8} m/s$
Electron Charge	$e = 1.6 \times 10^{-19} C$
Permeability of free space	$\mu_o = 4\pi \times 10^{-7} H/m$
Permittivity of free space	$\varepsilon_o = \frac{10^{-9}}{36\pi} F/m$

$$P_{rad} = 40\pi^2 \left[\frac{L}{\lambda}\right]^2 I_m^2$$

$$AF = a_1 e^{j\alpha_1} + a_2 e^{j(\beta d\cos\theta+\alpha_2)} + a_3 e^{j(2\beta d\cos\theta+\alpha_3)} + \ldots + a_N e^{j((N-1)\beta d\cos\theta+\alpha_N)}$$

$$|AF| = \frac{\sin(N\psi/2)}{\sin(\psi/2)}, \quad \psi = \beta d\cos\theta + \alpha \qquad \phi_{\max} = \cos^{-1}\left[-\frac{\lambda}{2\pi d}(\beta \pm m2\pi)\right]$$

$$P_D = \frac{P_{tx}G_{tx}}{4\pi R_{tx}^2} \qquad h_{inc} = \frac{D_1 D_2}{2KR} \qquad r = \sqrt{\frac{D_1 D_2 \lambda}{D_1 + D_2}}$$

$$E = \frac{\sqrt{30P_t \bullet G_t}}{d} \qquad E_R = 2\frac{E_0}{d}\sin\left(\frac{2\pi}{\lambda} \bullet \frac{h_t h_r}{d}\right)$$

$$n = \sqrt{\varepsilon_r} = \frac{\sin\theta_i}{\sin\theta_r} = \sqrt{1 - \frac{81N}{f^2}} \qquad MUF = f_{cr} Sec\theta_i$$

$$d = 2R\left[(\pi/2 - \beta) - \sin^{-1}\left(\frac{R}{R+h}\cos\beta\right)\right]$$

$$d_{\max.single\text{-}hop} = 2R\cos^{-1}\left(\frac{R}{R+h_{\max}}\right) \qquad \sin\theta_i = \frac{\sin\frac{d}{2R'}}{\sqrt{\left(\frac{h}{R'}\right)^2 + \left(1+\frac{h}{R'}\right)\sin^2\frac{d}{4R'}}}$$